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Comparisons of catches of large leptocephali using an IKMT and a large pelagic trawl in the Sargasso Sea

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Abstract:

Leptocephali of several elopomorph families can reach sizes of 100–300 mm or larger, but it is questionable if these large eel or notacanth larvae are effectively sampled by small-mesh sampling gear in the open ocean because of net avoidance or insufficient fishing effort. A sampling survey in the Sargasso Sea using both an Isaacs-Kidd Midwater Trawl (IKMT) with fine mesh and a large pelagic trawl with large mesh sizes found that fewer species and individual large leptocephali >100 mm were collected by 25 IKMT tows compared to 4 trawl deployments. Net avoidance of the IKMT by the larger leptocephali appeared to occur at least during the day, and the large trawl did not catch any small leptocephali because of the large mesh size. A combination of net avoidance of the IKMT and greater sampling effort of the much larger mouth-opening trawl seems to have resulted in more large leptocephali being collected by the trawl. This indicates that IKMT surveys undersample large leptocephali species and that large trawls do not sample the whole assemblage of leptocephali. To fully understand the biodiversity and abundance of leptocephali in the world's oceans, large fine-mesh sampling gear like the IKMT and very large trawls with smaller mesh will likely be needed. This may be important because leptocephali are probably more abundant in the open ocean than is realized, and their role in the ocean surface layer communities and carbon cycle is not understood.

Keywords: Leptocephali ; Elopomorpha ; Anguilliformes ; Sampling methods ; Net avoidance ; Sargasso Sea

1. Introduction

Understanding the biodiversity of inaccessible environments such as the pelagic realm of the open ocean depends on the ability to capture or observe the fishes and invertebrates present there in a short period of time using nets or camera systems. However, these methods have various limitations for sampling different types of organisms. For example, the success of video observation systems depends on the behavior of each type of animal (Koslow et al. *1995*; Stoner et al. *2008*), and fragile gelatinous zooplankton are easily damaged in nets making them unidentifiable in plankton or trawl samples (Remsen et al. *2004*). Most other macro-zooplankton or micronekton species show some degree of net avoidance of both pelagic trawls (Misund et al. *1999*; Kaartvedt et al. *2012*) or plankton nets (Clutter and Anraku *1968*). The ability of zooplankton to avoid nets may depend on advance detection distance that can be affected by visibility or disturbance of the water by the net or rigging (McGowan and Fraundorf *1966*; Wiebe et al. *1982*; Hovekamp *1989*; Stehle et al. *2007*). It is also clear that fish larvae can avoid plankton nets especially during daytime (Brander and Thompson *1989*; Morse *1989*; McGurk *1992*; Gartz et al. *1999*). Although various sampling gear designs have been devised for collecting zooplankton and micronekton, it may often be the case that using only one type of gear may not be sufficient to efficiently catch all sizes of the target organisms (Wiebe and Benfield *2003*; Skjoldal et al. *2013*).

Eel larvae, called leptocephali, are the unique larvae of eels and their close relatives that grow much larger than other fish larvae (Smith *1989a*) and therefore may have a greater ability to avoid nets (Miller *2009*). Many species of leptocephali grow larger than 150 mm, especially some larvae of the families Congridae and Nemichthyidae as well as the order Notacanthiformes (Böhlke *1989*; Smith *1970*, *1989b*, *c*) (Fig. 1). In oceanic waters, leptocephali are found in the upper 100 m at night, with some vertically migrating as deep as about 250 m during daytime (Castonguay and McCleave *1987*; Miller *2009*), so they can be captured by large plankton nets or trawls.

Various types of evidence suggest that leptocephali are able to frequently avoid capture by plankton nets, but this is not well documented. Catches of leptocephali with large plankton nets such as the Isaacs-Kidd Midwater Trawl (IKMT) or ring nets have been statistically lower during daytime than at night, apparently due to net avoidance (Castonguay and McCleave 1987; Miller and McCleave 1994; Miller et al. 2006). Leptocephali seem to have a good swimming ability in both forwards and backwards directions at least for some species (Wuenschel and Able 2008; Miller 2009), which may facilitate their net avoidance abilities, especially when they reach larger sizes. How much leptocephali can avoid large plankton nets at night has never been evaluated though, and larger pelagic trawls are rarely deployed in the open ocean with small enough mesh to collect leptocephali.

The objective of the present study was to examine the hypothesis that the largest leptocephali in the open ocean are significantly underrepresented in plankton surveys conducted with conventional nets such as the IKMT by comparing the catches of large leptocephali (>100 mm) by an IKMT to those by a much larger pelagic fisheries-type trawl deployed in the same areas and time periods.

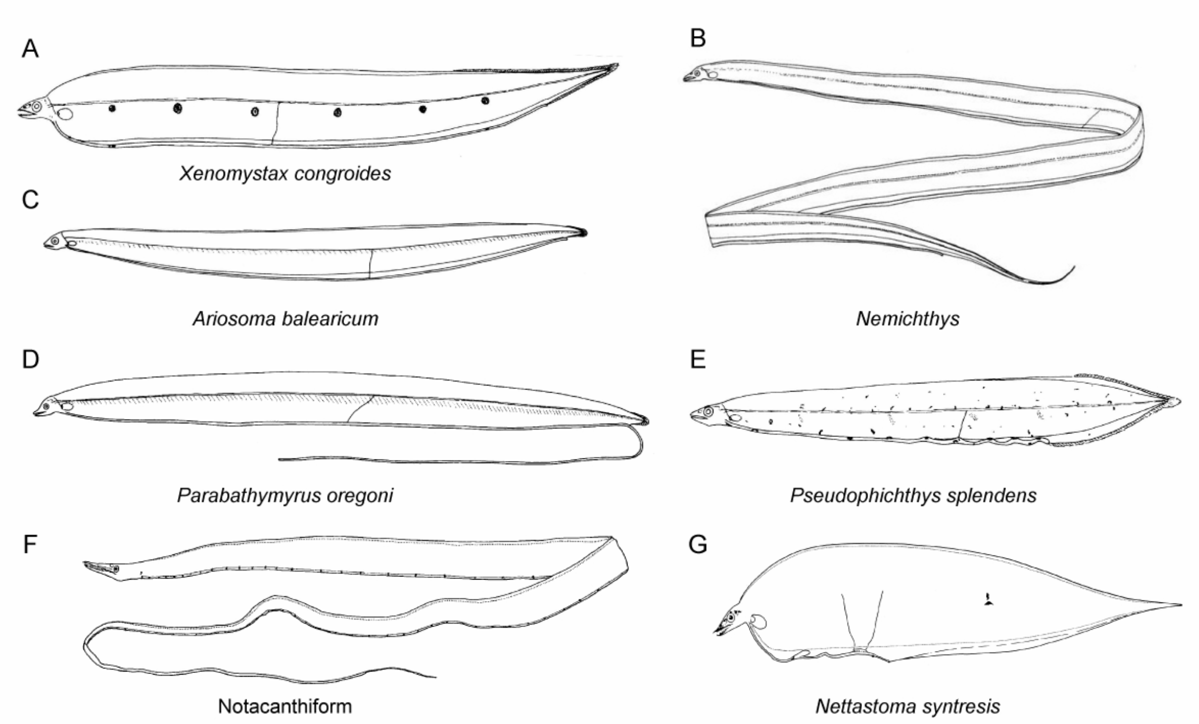

Figure 1. Drawings of species of leptocephali that reach large sizes or were more abundant in the large trawl. The species of congrids (A, C, D, E) (from Smith 1989b) and were caught at sizes of 131 – 241 mm in this study, the nemichthyid (B; *Nemichthys curvirostris*) (from Smith 1989c) and *Nemichthys scolopaceus* were caught up to a size of 438 mm as leptocephali and up to 810 mm as juveniles/adults, the notacanthid (F) is *Leptocephalus giganteus* (from Castle 1984), which can reach sizes of about 900 mm or larger (Castle 1959), and the *Nettastoma syntresis* (G) (from Smith and Castle 1982) was collected up to 83 mm in this study.

Materials and methods

The study was conducted from 16–25 March 2011 during the R/V *Walther Herwig III* cruise WH-342 using IKMT tows in 4 short transects (Stn. 3–32) that each included a pelagic trawl station (Fig. 2). Some IKMT tows conducted later in more northern or eastern areas where no trawls were conducted were excluded from this study (not shown). Each of the 4 transects included 5–8 IKMT tows (25 total tows) and 1 tow of the large pelagic trawl (4 total tows).

The IKMT (Hydro-Bios Apparatebau GmbH) had a 6.2 m^2 mouth opening with 0.5 mm mesh, a depressor, an upper spreader bar (no ring around the margin of the mouth opening) and a length of 10 m, and was deployed from the side of the ship using a single trawl wire. IKMT tows were made during night and day in 119–188 min deployments (double oblique tows, maximum depths about 300 m; mean ± SD: 160.4 ± 16.6 min per tow) with a mean towing speed of 2.3 kn.

The pelagic trawl (Engel Netze GmbH & Co. KG) had a width of 45 m, a height of 30 m, a length of 145 m, and decreasing mesh sizes from 180 cm grading down to 80, 40, 20, 10, 8, 6, 4 cm mesh and 2 cm mesh in the 27 m long cod end. The fisheries-type midwater trawl was deployed through the back of the ship using trawl cables on both sides of the ship. The trawls began just after midnight (start times: 00:09–00:17; maximum depths: 575, 516, 298, 304 m). Beginning at the maximum depth, fishing depth decreased stepwise during each tow (mean towing speed 3.4 kn). The depths of the gears were determined acoustically.

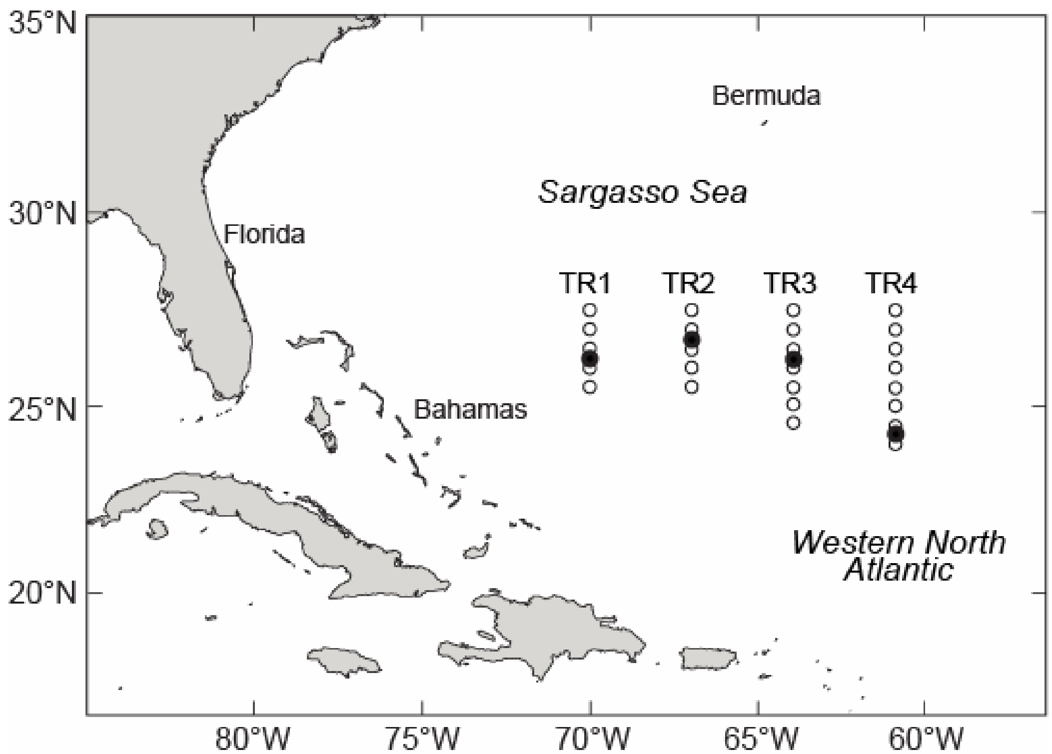

Figure 2. Map showing the sampling stations during the WH-342 cruise of the R/V *Walther Herwig III* that were used to compare catches of large leptocephali collected at stations that were sampled with the IKMT (white circles, n = 25) and a large pelagic trawl (black circles, n = 4) in 4 transects (TR1–TR4) in the Sargasso Sea from 16–25 March 2011.

All leptocephali were identified according to the information in Böhlke (1989) and Smith (1989b,c) and measured to the nearest mm (total length). Only two size categories of leptocephali that were > 100 mm were compared between the IKMT and large trawl, which were 101–150 mm and 151–485 mm. All much smaller leptocephali were not retained by the larger mesh of the large trawl.

In order to compare catches of only large leptocephali, the first step is to evaluate the effective fishing time of the two kinds of sampling gear (i.e., time fishing at depths and times of day where leptocephali can be caught). The deployments of the large trawl at night were attempting to collect spawning anguillid eels, which have now been collected in the Pacific Ocean using similar large trawls (Chow et al. 2009; Tsukamoto et al. 2011; Kurogi et al. 2011), so they fished much of the time too deep for catching large leptocephali that are usually in the upper 100 m at night (Castonguay and McCleave 1987; Miller 2009). Calculations of the time the trawl spent fishing in the upper 100 m where larger leptocephali would likely be present indicated the 4 trawls each fished from 22–60 min there (2.8 hours total), although the last trawl also fished 114 min mostly at 100 m after sunrise. So the trawls may have only sampled the correct depth layer to catch leptocephali for < 3–4 hours.

Similarly, although the IKMT tows fished for 12.0, 13.6, 19.5, 21.7 hours in total for transects 1–4 during all times of the 24 hr cycle, a proportion of those times would have been at inappropriate depths for catching larger leptocephali, because most species probably have a diel cycle of vertical migration (Castonguay and McCleave 1987). The effective fishing time of the IKMT tows can be separated into three categories. Tows that fished only at night (after sunset, before sunrise, 8 tows), where the leptocephali should mostly be within the upper 100 m (540 min fishing time). Crepuscular tows that fished across sunset or sunrise (7 tows) when an intermediate depth range could be used to estimate their likely catch layer (50–150 m, 320 min). Tows during the day (10 tows), when daytime depths could be about 150–250 m (502 min). In total, the IKMT may have been sampling for about 22.7 hours at the estimated effective depth layers in the three categories of tows. Each IKMT tow filtered approximately 44,607–88,594 m^3 (mean: 65,558.0 ± 11,273.7), but water filtered by the pelagic trawl could not be accurately estimated.

Results

The 25 IKMT tows with small mesh collected 824 total leptocephali of a wide size range (7–438 mm) compared to the 4 trawls with much larger mesh panels that only collected 181 leptocephali of a larger size range (40–485 mm) (Table 1, Fig. 3). Two juvenile/adult eels were also caught by the IKMT (Nemichthyidae, 545 mm; Serrivomeridae, 130 mm) and 10 were caught by the trawl (8 Nemichthyidae, 210–810 mm; 1 Serrivomeridae, 153 mm; 1 derichthyid juvenile, 82 mm). The IKMT leptocephali included 29 species of 13 families, and the trawl leptocephali included 22 species of 8 families.

For large larvae, 6 leptocephali > 150 mm (3 species) were collected in the IKMT, while in the 4 trawls, 40 leptocephali > 150 mm (8 species) were caught (Table 1). For the 101–150 mm size range, 16 larvae of 3 species were caught by the IKMT, and 31 larvae of 7 species were caught by the trawl. Combining the two categories there were 5 species > 100 mm caught by the IKMT and 12 species > 100 mm caught by the trawl, which included 6 species not caught by the IKMT at any size. This was a consistent pattern, because in each transect shown in Figure 2, there were 5–7 species of any size caught by the trawl that were not caught in the IKMT (Table 1). The reverse was also true for many species not caught by the trawl, but these were smaller species that all passed through the trawl mesh.

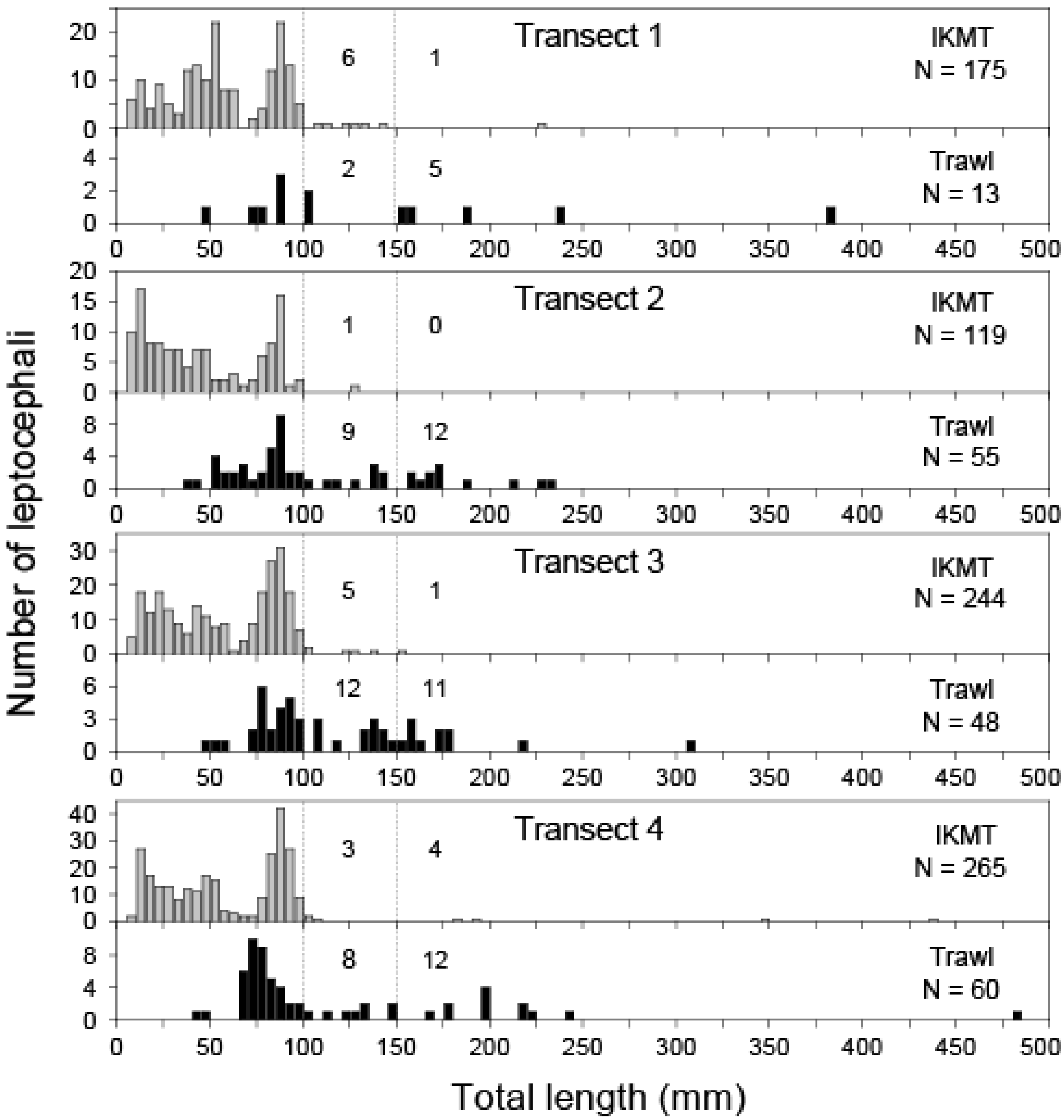

Figure 3. Length frequency distributions of the leptocephali collected by the IKMT and a large pelagic trawl along 4 transects in the Sargasso Sea. The IKMT retains all sizes of leptocephali that enter the net, but the larger mesh of the pelagic trawl would not retain many leptocephali < 70 mm in length. The dotted lines separate the two size categories of large leptocephali (101–150, 151–500 mm) and the numbers in the panels show the numbers of leptocephali of these two categories collected by each type of net.

Other differences were also seen in the compositions of the catches of both large and smaller leptocephali. Although there were 10 *Nemichthys scolopaceus* (Fig. 1B) leptocephali > 100 mm collected by the IKMT, only one undamaged larva of that species was caught by the trawl (237 mm; plus 2 heavily damaged larvae, likely of that species), suggesting that nemichthyids were well adapted to escape through the mesh of the trawl. In reverse, there were 10 metamorphosing leptocephali of *Ariosoma balearicum* caught in the trawl, but none were caught by the IKMT. Other types of congrids were also suggested to seemingly be avoiding the IKMT (assuming they were not less able to escape from the trawl), which were 34 *Gnathophis* leptocephali (61–118 mm) caught in the trawl, compared to 4 in the IKMT (67–90 mm), the 27 *Xenomystax congroides* (80–241 mm) in the trawl, compared to the 2 (191, 228 mm) in the IKMT, and the 9 *Bathycongrus* spp. in the trawl (132–186 mm), compared to 1 (185 mm) in the IKMT. Similarly, there were 23 nettastomatids of 3 species caught by the trawl (68–94 mm), but only 3 larvae of 2 species were caught by the IKMT (70–74 mm). In total, there were 8 species of 5 families (17 leptocephali) in the trawls that were not caught in the 25 IKMT tows (Table 1).

The largest leptocephali > 250 mm caught by the IKMT were 2 *Nemichthys scolopaceus* (349, 438 mm), and the largest caught by the trawl were 2 metamorphosing *Ariosoma selenops* (384, 485 mm) and a notacanthiform leptocephalus (309 mm). The other leptocephali >100 mm in the IKMT catches were mostly *Ariosoma balearicum* and *N. scolopaceus*, plus 3 other species also caught in the trawl. For those larvae > 100 mm caught in the trawl, the congrids *Xenomystax congroides*, *Bathycongrus* spp., and *A. balearicum* were most frequent. A few larvae of 3 other species >100 mm were also caught in the trawl (*Gnathophis sp.*, *Conger sp.*, *N. scolopaceus*), along with 5 *Pseudophichthys splendens* (103–131 mm), 2 *A. selenops*, 1 *Parabathymyrus oregoni* (187 mm), 1 *Bathycongrus* (1 of at least 2 species), which are congrids, and 1 Illyophinae (127 mm) (synaphobranchids), and 4 notacanthiform leptocephali >100 mm that were not collected by the IKMT (Table 1).

The length frequency plots of leptocephali showed that the numbers of larger leptocephali caught by the trawl were consistently higher in the 100–250 mm range, except at 100–150 mm in transect 1 (Fig. 3). Excluding all smaller leptocephali, the lengths of the leptocephali > 100 mm were significantly different between the IKMT (mean: 157.4 ± 83.8 mm; median: 128 mm) and trawl (168.6 ± 61.1 mm; 157 mm) (*t*-test, $p < 0.016$).

Excluding the trawl data, comparisons of the sizes of all the leptocephali caught in the IKMT at different times of day showed that the lengths of the larvae caught during tows made in night, day, and crepuscular periods were statistically different (Kruskal-Wallis test, $p < 0.001$). The length of larvae caught in night tows (8 tows, N = 267, mean ± SD = 64.1 ± 43.1 mm, median = 59 mm) and crepuscular tows (7 tows, N = 235, 61.1 ± 33.3 mm, 75 mm) were significantly different than those in day tows (10 tows, N = 300, 50.2 ± 29.5 mm, 45 mm) (Dunn's test, $p < 0.05$), but night tows and crepuscular tows were not significantly different. This difference was due in part to larger maximum sizes of leptocephali being caught in the night and crepuscular tows than in the day tows, because the largest leptocephali collected during daytime were 4 in the 101–150 mm range, compared to 7 leptocephali in the 101–150 mm range, and 4 > 150 mm (438 mm maximum size) being caught at night. There were 7 leptocephali between 101–200 mm collected in crepuscular tows that included some fishing time during night or darker periods.

Discussion

The present study had a unique opportunity to examine the catches of large leptocephali made by two very different types of sampling gear, because it included spatially overlapping deployments of both an IKMT and a large fisheries-type midwater trawl, which can not be deployed from most oceanographic vessels. The 4 trawl deployments collected more leptocephali of both size categories of the large leptocephali than the 25 IKMT tows, and collected 8 species of leptocephali not caught by the IKMT at any size. The trawl also collected more juvenile or adult eels of mesopelagic eel families. The estimation that the IKMT spent about 22 hours fishing at the appropriate depth layers during different times of the 24 hour cycle, but still collected far fewer large leptocephali compared to only about 3 hours of fishing time at appropriate depth layers at night by the large trawl indicated that the 25 tows of the IKMT did not effectively sample the assemblage of large leptocephali that were present in the areas where both types of gear were deployed.

There are two possible explanations for the observed differences in catches of large leptocephali between the two gears. One is that many of the large leptocephali that encountered the IKMT detected the net and avoided capture by swimming out of the way. This seems to have occurred at least during the daytime IKMT tows because the sizes of leptocephali were statistically different between night and day tows, and no leptocephali > 150 mm were caught during the day. This type of net avoidance is thought to occur for a variety of zooplankton and fishes (e.g., Clutter and Anraku 1968; Morse 1989), and it seems to have occurred for various sizes of leptocephali during previous daytime open ocean deployments of the IKMT, which caught significantly fewer leptocephali than at night (Miller and McCleave 1994; Miller et al. 2006), although this was not analyzed in detail. Castonguay and McCleave (1987) also found evidence of net avoidance of a large ring net by leptocephali during the day in the Sargasso Sea, and that most species vertically migrated from depths < 100 m at night to about 125 to 250 m during the day. The lower light levels at those depths may make them more vulnerable to capture during the day unless they are sometimes able to detect the net even in low light or using other senses. Like some zooplankton (Clutter and Anraku 1968; Hovekamp 1989), leptocephali may be able to detect a pressure wave in front of the net or other mechanical cues even at night, because leptocephali appear to have mechanoreceptors (Okamura et al. 2002). Visual cues might also sometimes be used by leptocephali to avoid an IKMT at night because bioluminescent organisms can accumulate on the mesh (Ross et al. 2007) or other parts of nets (Jamieson et al. 2006). This study could not determine if larger leptocephali also avoided the IKMT at night though.

The other possible contributing factor is that the much larger mouth opening of the trawl compared to the IKMT resulted in a greater amount of effective fishing effort for the larger, presumably rarer leptocephali because of the very large mouth opening, despite a shorter time period of effective fishing time. For example, due to the big difference in mouth opening size, the trawl would have filtered a much greater amount of water during 3 hours fishing in the upper 100 m at night than the 9 hours of fishing time at night by the IKMT at those depths. The large mouth opening of the trawl may not represent an effective fishing area though, because the mesh size in the outer regions of the net is 1.8 m, and most of the rest of the mesh is large enough for leptocephali to escape through if they attempt to do so. Similar to other types of fishes that show differences in how they are induced to remain inside the net or not (Heino et al. 2011), there may be behavioral differences among species of leptocephali inside the trawl or in their ability to escape through even the smaller mesh of the trawl. This is suggested for large *Nemichthys* leptocephali that were more abundant in the IKMT than the trawl, possibly because they have a very long-thin body compared to other large species (Fig. 1B). These types of factors and differences in filtering efficiency between the fine-mesh IKMT and the large-mesh trawl, seem to preclude presenting even simple calculations attempting to compare catch rates made using fishing time and mouth opening or using mouth opening, towing speeds, and estimated water filtered.

The problem of attempting to sort out which species may be avoiding-entering or escaping-from which type of gear may be even more complicated than initially imagined, because some species of leptocephali show distinct shape-change behaviors of curling up into fully or partially formed coil shapes when startled (Miller et al. 2013a). This type of behavior appears to have been selected for in leptocephali because it makes them appear similar in shape and consistency to gelatinous zooplankton (Miller et al. 2013a), which most fishes in tropical areas do not usually eat (Purcell and Arai 2001; Arai 2005). The likely presence of that type of behavior in many leptocephali suggests that some leptocephali that do not detect the net until it is very close, may curl up into these coiled shapes. If they hold the shape until inside the net, it could result in their capture especially by the IKMT that does not allow the chance to escape through the mesh.

The possible occurrence of this scenario is difficult to assess, but it probably does not happen all the time for large leptocephali that have the chance to avoid entering the net in advance. Possible evidence that some large leptocephali may be able to avoid IKMT nets even at night comes from data from this same area of the Sargasso Sea collected during 4 previous cruises (February-April, 1983, 1985) that included a greater fishing effort of 93 night tows of a larger IKMT (8.7 m^2 mouth opening) also with fine mesh (Miller and McCleave 1994). For example, in the present study 27 *X. congroides* (Fig. 1A) were caught in the 4 trawls (2 by the IKMT), but only 11 were caught in the 93 night tows in the previous study, which were mostly > 100 mm (maximum size 188 mm) (Miller and McCleave unpubl data). Similarly, 5 large *Pseudophichthys splendens* (Fig. 1E) were caught in the trawl and none were caught by the IKMT in this or the previous study, nor were any *A. selenops* (2 in the trawl).

The greater fishing effort of the larger mouth opening of the trawl would increase the probability of encountering rare large leptocephali per unit of time fished, but this alone does not seem to account for their lower frequency of capture in this study or the much greater fishing effort of Miller and McCleave (1994). It is likely that both net avoidance and a low probability of encountering rare individuals with a small mouth opening net result in multiple deployments the IKMT at night not effectively sampling the leptocephali > 100 mm in the Sargasso Sea or other open ocean areas. If true, this indicates that the leptocephalus collection data from IKMT surveys will likely consistently underestimate the biomass and biodiversity of leptocephali in open ocean areas. Similarly, it was found that deployments of a 50 m^2 trawl in the upper 500 m could catch larger individuals as well as species not previously caught in the area compared to a 5.4 m^2 IKMT (Pearcy 1980). The same was true for a 107 m^2 mouth opening trawl deployed in the bathypelagic zone compared to typical size oceanographic trawls (Stein 1985). It can be inferred from the data in Richardson and Cowen (2004) that many tows of standard sized plankton nets (1 m^2) are required to collect the same numbers caught in far fewer tows of a larger net, and some species were not collected in years when only the smaller net was fished. The present study also shows that fishing large mesh fisheries-type trawls are not an effective type of gear for sampling leptocephali even if they are better at catching large leptocephali than the IKMT per unit of deployment time, because the trawls obviously do not catch the smaller leptocephali.

Except for *N. scolopaceus*, the largest leptocephali caught in the present study were all larvae of eels that live on the continental shelf or slope (Table 1) and were probably drifting offshore longer than needed to complete their larval growth period. Some leptocephali seem to be able to delay metamorphosis if they are not near recruitment habitats (Miller 2009), as exemplified by *X. congroides* leptocephali often being caught at pre-metamorphic sizes larger than the minimum metamorphosing size of that species (Smith 1989b). There may be many of these large leptocephali drifting offshore far away from their recruitment areas that are rarely caught by plankton nets or may often pass through the mesh of large fisheries trawls and thus go undetected. Other types of open ocean leptocephali that may be undersampled are the large notacanthids that have been caught at sizes of about 200–900 mm, but can apparently reach sizes up to 1.8 m long (Castle 1959, Smith 1970; Tabeta 1970; Figueroa et al. 2008). These large larvae seem to be rarely collected except by fisheries trawls.

One reason this issue of under-sampling of leptocephali may be important is that leptocephali are different than other fish larvae because they feed on particulate organic matter such as marine snow (Otake et al. 1993; Mochioka and Iwamizu 1996; Miller et al. 2011) making them have a very low isotopic trophic signatures (Miyazki et al. 2011; Miller et al. 2013b). Because they do not feed on zooplankton like other fish larvae, but instead feed directly on particulate organic matter, they are a presently unrecognized component of the lower trophic levels of the carbon cycle in the ocean surface layer (Miller 2009; Miller et al. 2013b). Therefore understanding the biodiversity, abundance and size structure of leptocephali will be of critical importance to learning more about the ecological role they play in the world's oceans.

The issue of under-sampling of leptocephali may also be important because juvenile and adult eels are difficult to collect in their benthic or deep-ocean habitats, so collections of leptocephali are a good way to evaluate how many species of eels are in each region of the world (Wouthuyzen et al. 2005). Therefore, effective sampling techniques for leptocephali may be important for future efforts to understand the biodiversity of marine eels.

The present study suggests that large leptocephali could be present in many areas, but they are under-sampled even by the large plankton nets used to collect leptocephali, as has been proposed for mesopelagic fishes (Kaartvedt *et al*., 2012). Similar to zooplankton for which no single net seems suitable to collect all size ranges because of mesh size or net avoidance factors (Skjoldal et al. 2013), two types of nets/trawls will likely be needed to effectively sample all sizes of leptocephali. This is supported by the finding that single or just a few deployments of a 70 m^2 midwater trawl lined with 2 mm mesh (Dennis et al. 2001) deployed in many areas of the northwest Coral Sea collected more leptocephali than the total number caught in the present study (MJ Miller and JE Leis, unpubl data). Therefore, studies of leptocephalus assemblages or their biomass need to consider the likelihood that the largest leptocephali will not be collected in numbers reflecting their true abundance unless large pelagic trawls with small mesh are also used.

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Table 1. Number of each species of leptocephali collected in each IKMT transect (T1 to T4), which included a single large trawl (TR1 to TR4) deployment, also showing the number of large leptocephali of the two size categories, with the numbers caught in the IKMT shown in parentheses. The life history category (LH) of the adults of each species is listed as being either catadromous (CT), continental shelf (SH), outer shelf and slope (SL), oceanic (OC), or deep slope (DS).

Species	LH	IK T1	TR1	IK T2	TR2	IK T3	TR3	IK T4	TR4	101-150 mm	151-485 mm
Anguilla spp.	CT	17		13		6		3			
Ariosoma balearicum	SH	45	4	35	18	124	11	121	12	9 (8)	8
Ariosoma selenops	SH		1						1		2
Parabathymrus oregoni	SH				1						1
Conger spp.	SH	2		2	1		1	1		2 (1)	
Gnathophis spp.	SH		2		18	2	9	2	6	3	
Bathycongrus spp.	SH		1		3		4	1	1	6	3 (1)
Pseudophichthys spendens	SH		1				2		3	5	
Xenomystax congroides	SH	1			6		12	1	9	4	22 (2)
Chilorinus suensonii	SH	1	1	2	1	2		1	1		
Chlopsis spp.	SH	1			5	3	2	3			
Catesbya pseudomuraena	SH					1					
Kaupichthys hyoproroides	SH			1	1	1		4			
Robinsia catherinae	SH				1	1	1				
Unident. Chlopsidae	SH			1				1			
Moringua edwardsi	SH	2		1							
Anarchias similis	SH	4		6		10		18			
Gymnothorax miliaris	SH							2			
Muraenidae *sp.*	SH	1				1					
Myrophis punctatus	SH	1									
Nettastoma syntresis	SL		1			1	1	2	19		
Nettenchelys sp.	SL						1		2		
Ilyophinae spp.	SL		1			1	3	2	4	1	
Synaphobranchinae	SL	1									
Derichthys serpentinus	OC	1		2		1		3			
Derichthyidae sp	OC					3		3			
Derichthyidae juvenile									1		
Avocettina infans	OC			3		6		13			
Nemichthys scolopaceus	OC	79		13	1	56		63		(7)	1 (3)
Unident. Nemichthyidae	OC		1	1					2		
Nemichthyidae juv./adult	OC		1				1	1	6		8 (1)
Serrivomer beanii	OC	16		17		15		13			
Serrivomer lanceolatoides	OC	2		16		14		17			
Serrivomer sp.	OC					4					
Serrivomer juv./adult	OC							1	1		1 (1)
Eurypharynx pelecanoides	OC	5		7		15		10			
Cyema atrum	OC								1		
Leptocephalus holti	OC					2					
Notacanthiform	DS						1		2		3
Unident. leptocephalus				2		1		5	1	1	
Total		179	14	122	56	270	49	291	72	31(16)	49(8)
Number of tows		5	1	5	1	7	1	8	1		